Determining the Growth-maximizing Threshold Level of Inflation in Bangladesh

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Abstract

The relationship between GDP growth and inflation has been examined empirically with mixed results. Some studies show that the relationship between GDP growth and inflation is positive while others show a negative relationship between them. This paper has examined the relationship between economic growth and inflation with a threshold estimation method. This study based on time series annual data over a sample period from 1977-2015, shows a threshold level of inflation at 6.25 percent implying that inflation higher than that level appears to have affected economic growth negatively, while inflation and growth move positively for any level of inflation below the threshold. However, threshold level changes over the decades depending on trends of these two variables. The paper suggests that controlling price above the threshold level is prerequisite of sustainable growth in Bangladesh.

Keywords: Inflation, economic growth, causality, threshold, robustness

JEL Codes: E31, C22, O53

1. Introduction

Inflation and economic growth are the most crucial variables in macroeconomics. Determining whether inflation is harmful to economic growth, in particular, to what extent it is undesirable, are factors that are of great importance to macroeconomists, researchers, policy makers, and monetary authorities of all the nations. That is why the relationship between inflation and economic growth has generated so much discussion and has resulted in so much debate both in the case of theoretical and empirical findings. The controversy ensues from two main schools of economic thought i.e. the structuralists, who hold the view that inflation is essential for economic growth and the monetarists, who insist that inflation is detrimental to economic progress. Friedman (1973:41) concluded that the inconclusive nature of the relationship between inflation and economic growth as follows: historically, all possible combinations have occurred e.g. inflation with and without development, no inflation with and without development, etc. In many developing and emerging markets, the upsurge in inflation might pose pressure to economic growth and that is why many policy makers and researchers have diagnosed and tried to way out by establishing a relationship between inflation and the economic growth. The most important questions in this context are: whether inflation and growth are inversely related or not? Is the inflation-economic growth relationship primarily a long-run or a short-run relationship across time?

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The existence of a negative link between inflation and economic growth has been observed in many studies where it has been conducted on time-series or cross-sectional data of a developed or developing country. The controversy has leads to theorists reaching a consensus that, if in a county there is economic stability with a low level of inflation (may be a single digit inflation) then inflation may prove to be helpful in promoting growth. (Mubarik, 2005). This further depends upon the economic environment of that country and the relationship may produce different results for different countries.

With this perspective econometricians have introduced a meaningful technique to establish the relationship between inflation and economic growth. As per this technique a verge point regarding inflation has been utilized which determines the effects of inflation on economic growth. Up to that verge point the inflation level is conducive to accelerating economic growth but beyond that inflation affects economic growth negatively (Sweida n, 2004).

Barro (1990) reports a negative but weak relationship between inflation and growth rate of real GDP during 1970-1985 in a cross-section of 117 countries. Fischer (1993) concludes that a surge in inflation is detrimental to the growth in output as it negatively impacts investment and productivity as well. Bruno and Easterly (1996) found that growth and high inflation is positively related in the short run and negatively related in the long run using different panels that episodes of high inflation corresponded with negative growth in output. They find no evidence of any relationship between inflation and growth at an annual inflation rate less than 40 percent defined as high inflation. They do find a short-to medium run negative relationship between high inflation and growth and there is no lasting damage to growth from discrete high inflation crisis as countries tend to recover back towards their pre crisis growth rate. Ghosh and Phillips (1998) have studied the relationship between inflation and economic growth in 145 countries and concluded that there is a positive relationship between inflation and economic growth when inflation is low but the relation becomes negative for high inflation. Moreover, they have observed that decline is much steeper at a higher level of inflation depicting a convex relationship between the two variables.

Gerloch and Smets (1999) show that a 1% increase over potential output raises inflation by 0.2% in the subsequent quarter in the EMU-5 countries. Moreover, since inflation is serially correlated, future inflation rates will also rise. A study was conducted by Paul et al. (1997) using data of 70 countries from the 1960-1989 period. They reported that the relation between inflation and growth is positive only in some countries. Mallik and Chowdhury (2001) analysed inflation-growth dynamics in four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka) using annual data based on co-integration and error correction methods and found statistically significant evidence of a positive relation between the two variables though they did not determine any threshold level or growth inflation nexus for these countries. Bhaduri (2013) revisits the nexus between inflation and growth from the perspective of an emerging economy, India. Exploring this relationship using a wavelet multi-resolution analysis shows a strong and persistent negative relationship between growth and inflation for a short span of time, while it is not significant for a longer time scale.
A very few studies have been conducted on the relationship between inflation-growth in Bangladesh. In the context of Bangladesh, a study by Ahmed and Mortaza (2005) empirically identified the nexus between inflation and economic growth using annual data on real GDP and CPI for the period of 1980-2005. They showed a statistically significant long-run negative relationship between inflation and economic growth as well as a threshold level of 6 percent inflation for Bangladesh. This study indicates a non-linear relationship between inflation and economic growth that is under a certain level of inflation, the relationship is positive and beyond that level of inflation, the relationship is negative.

Paul (2012) examines the inflation growth nexus for Bangladesh over the period 1976-2009 in a EGARCH-M model and finds that both growth and inflation adversely affect each other in a lagged fashion in Bangladesh. Inflation uncertainty appears to be conducive to growth for the country, contradicting the Friedman hypothesis.

Hayat (2012) reexamines the existence of a threshold level of inflation in Bangladesh for the period 1977-2011 using two different estimation techniques. The empirical analysis finds that the threshold level above which inflation significantly slows growth is about 5.5 percent. Younus (2012) estimates the growth inflation tradeoff threshold in Bangladesh, covering data from 1976 to 2012, which demonstrates that the relationship between inflation and growth is non linear with the existence of a threshold level of inflation within the range of 7-8 percent. A simple implication of this kind of relationship between inflation and economic growth is that a modest increase in the rate of inflation would not be harmful for the long-run real economic growth for the economies with initially low rates of inflation. But for economies that have initially high rates of inflation, a further increase in the inflation rate would have adverse effects on real economic growth. However, recent data and the present situation implies that around 6 percent of inflation rate is a tolerable level and the government should set a target of inflation around this level.

However, because of the discrepancies in the findings of different studies in the context of Bangladesh, further investigation is needed with recent data and methods, to explore the extent to which inflation affects economic growth.

In this perspective, it is important to investigate the inflation-growth nexus in developing countries like Bangladesh. The relationship between growth and inflation is usually positive for a certain level of inflation. Policies like expansionary fiscal and monetary policies fuel initiate demand which, in turn, accelerates output and commodity prices. High Inflation is undesirable because it adversely affects the poor in particular, distorts relative prices, and erodes purchasing power, standard of living and value of the financial assets. The ultimate policy objective is a better standard of living for the people; but there is always a dilemma regarding the means to achieve it: through higher economic growth or lower inflation. There is a link involved but both cannot be achieved in the same basket.
The objective of this study is to examine the inflation-growth nexus empirically in Bangladesh using annual data for the period FY1977 – FY2015. Secondly, this study will be able to find out the best level of inflation rate for Bangladesh economy. Finally, the study has an objective to cushion efficient and effective policy recommendations for the future.

2. Relationship Between Inflation and Economic Growth: Cross Country Scenario

Many studies show that the inflation and growth relationship varies across countries and group of countries. Paul et al. (1997) using data of 70 countries from 1960-1989 periods reported that the relation is positive only in some countries. Mallik and Chowdhury (2001) analyzed inflation-growth dynamics in four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka) and found statistically significant evidence of a positive relationship between the two variables. In order to have a clear understanding about the relationship between inflation and economic growth using data from IFS (International Financial Statistics) the investigator has made three groups and uses the following graph.

2.1 Advanced Countries’ Situation

The figure 1 shows that in case of advanced economies lower rate of inflation exits with lower level of growth overtime. The relationship between inflation and growth is quite positive and growth and inflation moves in same direction - an increase in the inflation rate raises economic growth and vice versa. The figure 1 also depicts the recession period when inflation and growth was too low, even negative during 2009.

2.2 Emerging Market and Developing Economies Situations

In figure 2, the relationship between inflation and GDP growth in Emerging Market and Developing Economies is shown. Here, inflation and growth is at the same level and almost above 5 percent. The relationship between these two variables over time represented in the graph is positive for the group.
2.3 South Asian Scenario

To examine the relationship between inflation and economic growth in South Asian countries is important due to its complex nature. The relationship between inflation and economic growth is roughly possible to see from the graph. The figure 3 depicts how difficult it is categorically to say whether inflation and economic growth are positively or negatively related. However, the figure 3 shows that in the case of Bangladesh, Sri Lanka and Maldives, inflation and growth were at the same level during 2003, while Bangladesh and Sri Lanka were attributed with high inflation and high growth and Maldives saw low inflation with low growth, India, Pakistan and Nepal were plagued by high inflation and lower growth compared to the neighbouring countries.

3. Theoretical debate on the inflation-growth nexus

Adam Smith as the father of classical theories says that, the factors of production and the production technology determine the economy’s output of goods and services. An increase in one of the factors of production or technological advances raises output. He posited that the competition among capitalists for workers would bid wages up resulting in a higher cost of production and lower profit. The link between the changes in price level (inflation) and its tax effect on profit levels and output were not clearly articulated in classical growth theories. But the relationship between the two variables is implicitly suggested to be negative as indicated by the reduction in firm’s profit levels through higher wage costs. (Gokal and Hanif, 2004).
In 1936, the British economist John Maynard Keynes established Keynesianism by writing his prominent book “The General Theory of Employment, Interest and Money”. Keynes believes that in the short run prices are sticky, so changes in aggregate demand influence income. He also believes that intervention in economy by government through expansionary economic policies will boost investment and promote demand to reach full production. The Keynesian model is based on Aggregate Demand (AD) and Aggregate Supply (AS) curves which illustrate the relationship between inflation and growth. In this model aggregate supply (AS) curve behaves differently in the short run than in the long run. In the long run prices are flexible and the AS curve is vertical. When the AS is vertical, shifts in the aggregate demand curve (AD) affect the price level but the output of the economy remains at its natural level. By contrast in the short run, prices are sticky and the AS curve is upward sloping in the real world. In that case the change in the demand side of the economy affects both price and output (Dornbusch, et al, 1996).

Dornbusch, et al (1996) also postulates that AD and AS yields an adjustment path which shows an initial positive relationship between inflation and economic growth but eventually turns negative towards the latter part of the adjustment path. The initial positive relationship between inflation and economic growth is due to the time inconsistency problem. Blanchard and Kiyotaki (1987) said inflation and economic growth are positively related because of the agreement of firms to supply on agreed price. So the firm has to produce even at an increased price. Later on the relationship becomes negative. This describes the phenomena of stagflation, that is, output decreases or remains the same when the price rises (Gokal and Hanif, 2004).

Monetarism established by Milton Friedman, focuses on the long-run supply side properties of the economy as opposed to short-run dynamics. The long-run properties of the economy include Quantity Theory of Money and the Neutrality of Money. This school claims that the money supply is the only factor that determines price levels in an economy. They argued that government intervention manages the growth rate of the money supply to harmonize it with the growth rate of output in the long run. Monetarists argue that inflation will occur when the money supply rises faster than the rate of growth of national income. But the effect of money supply is different for the long run and short run.

In the short run, money supply has the dominant influence on real variables (i.e. real GDP and employment) and the price level. But in the long run, the influence of variation in the money supply is primarily on the price level and on other nominal variables but not on real variables like output and employment (Richard Froyen,1998). Monetarism incorporated the concept of anticipation into Phillips curve and divide the Phillips curve into short run and long run sections. For this theory the Phillips curve will hold in the short run but not in the long run. In the long run, anticipated inflation will be consistent with actual inflation. When anticipated inflation is consistence with actual inflation then inflation will not influence unemployment, output and other real economic variables. Gokal and Hanif (2004) describe this concept as the ‘neutrality of money’.
The neoclassical growth model added by Solow and Swan focuses on scientific innovation or technological advancement replaced investment (growth of capital) as being the primary factor to explain long term growth and level of technological advancement is determined exogenously, which is independent of all other factors including inflation. Gokal and Hanif (2004) explained that in neoclassical economics the theory of growth is built on a concept of diminishing returns to labor and capital separately and constant returns to both factors jointly. Technology, labor and capital are the main determinants of output growth in neo classical growth theory. Economists in neo classical growth gave their own explanation about the relationship between inflation and economic growth.

According to Mudell (1963), inflation might permanently increase output growth rate by stimulating capital accumulation, because in response to inflation, households would hold less in money balance and more in other assets. Tobin (1965) also supported Mundell’s idea that inflation is positively related to economic growth. Contrary to Mundell and Tobin idea, Stockman (1981) developed a model that shows a negative relationship between inflation and economic growth. Stockman’s model shows that an increase in the inflation rate results in a lower steady state level of output and a decline in people's welfare. In Stockman's model, money is a compliment to capital, accounting for a negative relationship between the steady state level of output and the inflation rate. But it is substitute goods for Mundell and Tobin. In this theory there is no relationship between inflation and economic growth. Sidrauskin (1967) said that an increase in the inflation rate does not change the steady capital stock and economic growth.

In the endogenous growth theory, the rate of return on capital i.e. human capital and physical capital determine the growth rate. A tax on either form of capital induces a lower return. Macallum and Goodfriend (1987) said that the inflation rate (tax) lowers both the return on all capital and the growth rate. (Fikirte Tsegaye Mamo, 2012).

4. Threshold Level of Inflation

Price stability is the prime objective of monetary policy; the expectation of an appropriate rate of inflation leading to optimal GDP growth should be emphasized for any country. International evidence shows a wide range for estimates of threshold inflation. Khan and Senhadji (2001), in their study using panel data, based on a cross-country regression (140 countries), over the period 1960-1998, concluded, that the point beyond which inflation retards growth is between 1 and 3 percent for industrial countries and between 7 and 11 percent for developing countries. The results suggest that the threshold is not fixed over time across countries - it is time varying and country specific in nature. Mubarik (2005) studied data for Pakistan for a wide sample period of 1973-2005 and concluded that beyond 9 percent, inflation affects growth adversely while at a moderately low level of 5 percent, inflation positively influences growth.

Since the second half of the 1990s, a number of studies were conducted to estimate threshold inflation for India. But different studies in the Indian context have provided differing views on the
inflation threshold. In the long run, high inflation is correlated with a lower level of economic growth; several other studies have examined this finding for a single country over time. Rangarajan (1997) analyzed data for India and established the range of 5-7 percent which has been further confirmed by Samantaraya and Prasad (2001) who suggested that 6.5 percent is the estimated threshold.

The Chakravarty Committee (RBI, 1985) referred to an inflation rate of 4 percent as an acceptable rise in prices. This is regarded as the first influential fix on the threshold rate of inflation in India. More studies made estimates of threshold inflation using the Sarel methodology and these estimates place threshold inflation for India in the range of 4-7 percent (Kannan and Joshi, 2002; Vasudevan, Bhoi and Dhal, 1998). A study by Singh (2010) which used both, yearly and quarterly data, found the threshold level of inflation for India at 6 percent but failed to confirm the same with the Sarel (1996) methodology.

Using annual data from 1970 to 1990 for 87 countries, Sarel (1996) found that the threshold is at 8 percent, below which the effect of inflation on growth is negligible (or slightly positive) but beyond 8 percent there is a significant, extremely powerful negative effect on economic growth. Drukker, Gomis-Porqueras and Hernandez-Verme (2005) confirmed the existence of a threshold level using a panel of 138 countries, but they estimated its level to be higher, at about 19 percent. This level of threshold, higher than usually estimated, was confirmed by Pollin and Zhu (2006) who also divided the sample by decades and suggested that the threshold would be around 15-18 percent.

A much lower threshold was obtained by Burdekin et al. (2004), who estimated a panel model of 72 countries using annual data and allowing for multiple thresholds, found that for developing countries, inflation proves to be costly when it is higher than 3 percent. Espinoza et al. (2010) used a panel of 165 countries for a period of 1960–2007 where they estimated a threshold of about 10 percent for all country groups (except for advanced countries) above which inflation quickly becomes harmful to growth. However, for the advanced economies, the threshold was much lower.

5. Historical Trends in Inflation and Economic Growth in Bangladesh

Bangladesh is considered as a potential and growing economy in the South Asian region. We may observe movements in economic growth and inflation in different decades of Bangladesh economy during the period FY1977-FY2015. After liberation up to the 1980s, GDP growth rates of Bangladesh abnormally fluctuated from 1.31 to 12.25 percent while inflation rates followed the same pattern which showed up and down from a negative figure of -6.75 to 39.12 percent.

Here we explored mainly the data of inflation and GDP growth in Bangladesh for FY1981 to FY2015. The decade average inflation rate depicted 10.27 percent whereas the average GDP growth was 4.01 percent during FY1981 to FY1990. Similarly, during FY1991 to FY2000, the decade average
inflation rate went down significantly to 5.54 percent which was about half of the previous decade and the GDP growth surged moderately to 4.80 percent from 4.01 percent (figure 4).

![Figure 4: Historical data: Inflation-GDP Growth](source: BBS, 2015)

Afterwards, the decade-average GDP growth was recorded at 5.82 percent, along with the decade-average CPI inflation which was also documented at 6.25 percent during FY2001 to FY2010. So, it is evident that during two decades (1981-2000's), high inflation rate remained detrimental to economic growth. Data of the current decade showed that the average CPI inflation stood at 8.43 percent and real GDP growth was 6.27 percent. From this historical data, it is seen that when inflation rate was much higher, real GDP growth recorded a lower rate. Here the important point is that the degree of relationship between GDP growth and inflation depends on the threshold level inflation of a particular country. If the inflation rate is much lower compare to the threshold rate, the relation may be positive or weak and vice versa. It is a fact that concrete conclusions could not be drawn through visual examination but an inverse relationship between economic growth and inflation rate could easily be inferred throughout the period under the study.
This scatter diagram depicts the level of inflation rate and its corresponding real GDP growth.

From the above figure 5, a non linear relationship between inflation and real GDP growth and the threshold level of inflation is clearly be seen which is between 6-7 percent where Younus (2012), in his study, shows a diagram which depicts a threshold level of inflation with the range of 7-8 percent.

The growth-inflation relationship could be easily understood through portraying their trends over time. Hence, we deconstructed the data for the period (FY1977-FY2015) within 5 grouped observations where we have estimated the average economic growth for each span of inflation (table 1).

**Table 1: GDP Growth-Inflation Relationship**

<table>
<thead>
<tr>
<th>Level</th>
<th>Sample Size</th>
<th>Inflation Range (%)</th>
<th>Average GDP Growth %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Level</td>
<td>4</td>
<td>up to 3.00</td>
<td>4.40</td>
</tr>
<tr>
<td>2nd Level</td>
<td>6</td>
<td>3.01-5.00</td>
<td>5.25</td>
</tr>
<tr>
<td>3rd Level</td>
<td>5</td>
<td>5.01-7.00</td>
<td>5.74</td>
</tr>
<tr>
<td>4th Level</td>
<td>11</td>
<td>7.01-9.00</td>
<td>5.13</td>
</tr>
<tr>
<td>5th Level</td>
<td>13</td>
<td>above 9.00</td>
<td>4.37</td>
</tr>
</tbody>
</table>

Source: Author’s own calculation from BBS data

The groups show that when the inflation rate is ranging from 0 to 3 percent, it shows an average GDP growth rate of 4.40 percent. As the inflation reaches the range of 3.01-5.00 percent and 5.01 to 7.00 percent, GDP growth rate goes up gradually to 5.25 percent and 5.74 percent respectively. However, the 4th and 5th levels show a gradual decrease in average GDP growth which indicates the negative relationship between inflation and GDP growth rate. It is clear from the above observation that when inflation is at the 3rd level ranged from 5.01 to 7.00 percent the average GDP growth is at the highest...
level (5.74 percent). The relationship between inflation range and average GDP growth rate is shown in figure 6.

From the above figure, we find the results are the same as stated in the table 1 which means that when inflation is at the range of 5.0 to 7.0 percent, average GDP growth is at the highest level.

Historically, it is found that inflation is higher and growth is lower before FY90 as compared with those after FY90. The figure 7 shows the relationship changes over the years. Before FY90 average inflation was much higher than that of the following years after FY90 and onwards. On the other hand, average GDP growth before FY90, was much lower than after FY90 and onwards. In the first period, it is observed that inflation is much higher than growth while later period the difference between growth and inflation is very small.

To examine the relationship between inflation and GDP growth we simply estimate a simple OLS regression taking inflation as independent and GDP growth as dependent variables using annual data from 1977 to 2015. Yearly data on consumer price index on the latest base year is used for inflation.
in different time periods and real GDP growth (annual percent) is used on the basis of the latest base year for the periods FY1977 to FY2015 which have been collected from Bangladesh Bureau of Statistics (BBS).

To estimate the threshold level of inflation, many studies have been conducted using several econometric techniques. Among them, we followed the methodology adopted by Sarel (1995) where he introduced a new methodology for estimating threshold inflation by incorporating the concept of ‘extra inflation’. He defined π* as the rate of inflation at which a structural break occurs. Then, he designed the model incorporating a dummy variable to introduce the concept of ‘extra inflation’ which is defined by introducing a dummy variable, D such that D=1 in case π > π* and D=0 if π<π*. Then, an OLS regression is estimate for the growth rate on the two variables π and extra inflation [D (π−π*)].


6.1 Model Specification

Simplified Model

The simplified model is specified as follows:

\[ y_t = \alpha + \beta_1 \pi_t + u_t \]  

where \(y_t\) = real GDP growth, \(\pi_t\) = inflation rate.

Threshold Model

By incorporating the extra inflation term in equation (1), the threshold model is specified as follows:

\[ y_t = \alpha + \beta_1 \pi_t + \beta_2 D_t (\pi_t - \pi^*) + u_t \]  

where \(D_t\) = dummy for extra inflation, \(\pi^*\) = assumed threshold inflation, \(D_t = 1\), if \(\pi_t > \pi^*\) and 0 otherwise.

When \(D_t = 1\), then equation (2) appears as the following:

\[ y_t = \alpha + \beta_1 \pi_t + \beta_2 (\pi_t - \pi^*) + u_t \]  

This is equation (3).
Equation (3) reveals the impact of inflation and extra inflation on GDP growth. The impact on GDP growth with respect to inflation is the sum of the coefficients i.e. \( \frac{dy}{d\pi} = \beta_1 + \beta_2 \)

When \( D_i = 0 \), then equation (2) becomes simplified as stated below:

\[
y_t = \alpha + \beta_1 \pi_t + u_t \quad \text{........... (4)}
\]

Equation (4) is similar to equation (1) which indicates the simple relationship between inflation and GDP growth, where \( \frac{dy}{d\pi} = \beta_1 \).

By prior expectation we expect \( \beta_1 > 0 \) and \( \beta_2 < 0 \) because extra inflation has a negative effect on GDP growth. By assumption a small unit change from the threshold level causes harm to GDP growth. But for determination of the threshold level, the magnitude of \( \beta_2 \) must be so large so that the sum of the coefficients of both inflation and extra inflation must be negative i.e. \( (\beta_1 + \beta_2) < 0 \).

**Quadratic Model**

For checking the robustness of the threshold model we also with find a non-linear relationship between inflation and economic growth using the same data set. The estimating non-linear model is defined as the following quadratic equation.

\[
y_t = \alpha + \beta_1 \pi_t + \beta_2 \pi_t^2 + u_t \quad \text{........... (5)}
\]

It is expected that \( \beta_1 > 0 \) and \( \beta_2 < 0 \).

For finding the threshold level of inflation from the quadratic model shown in equation (5) following two conditions to be satisfied to get maximum level of GDP growth.

i) \( \frac{dy_t}{d\pi_t} = 0 \) and

ii) \( \frac{d^2 y_t}{d \pi_t^2} < 0 \)

**6.2 Econometric Method**

In search of the threshold level of inflation the OLS regression will be applied iteratively with different assumed structural break (\( \pi^* \)) values. The structural break \( \pi^* \) ranges/takes values from 3 to 9. There are few observations below 3 or above 9 percent inflation rate. Estimating OLS regression taking different structural values (\( \pi^* \)) will generate a series of regression estimates.

Among the series of regression estimates, we determine the threshold level of inflation \( \pi^* \) at which a structural break is suspected with the highest \( R^2 \) or minimum residual sum of squares (RSS) along with the sum of the coefficients of both the level of inflation (\( \pi_t \)) and extra inflation (\( \pi_t - \pi^* \)) which is negative and statistically significant. It means a one unit increase in inflation above the
threshold level results lower GDP growth. Extra inflation more than the threshold level harms GDP growth. Inflation below the threshold level is tolerable and higher GDP growth is possible by allowing inflation up to this threshold level.

7. Empirical Results

Correlation between GDP growth and inflation

The correlation matrix of historical data from FY77 to FY15 shows that there is a negative significant relationship between GDP growth and inflation. The correlation coefficient between GDP growth and inflation is 0.39 which is statistically significant at 5%.

Unit root test

Before applying OLS we checked stationarity of our time series variables through Phillips-Peron and the Augmented Dickey-Fuller Unit Root Tests are shown in table 2.

<table>
<thead>
<tr>
<th>Variables in Levels</th>
<th>Phillips-Peron Test</th>
<th>Augmented Dickey-Fuller Test</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With intercept</td>
<td>With intercept and trend</td>
<td></td>
</tr>
<tr>
<td>GDP growth ( y_t )</td>
<td>-4.76 ( (0.00) )</td>
<td>-8.97 ( (0.00) )</td>
<td>No unit root</td>
</tr>
<tr>
<td></td>
<td>-2.51 ( (0.12) )</td>
<td>-7.13 ( (0.00) )</td>
<td></td>
</tr>
<tr>
<td>Inflation ( \pi_t )</td>
<td>-5.15 ( (0.00) )</td>
<td>-5.59 ( (0.00) )</td>
<td>No unit root</td>
</tr>
<tr>
<td></td>
<td>-5.15 ( (0.00) )</td>
<td>-5.66 ( (0.00) )</td>
<td></td>
</tr>
</tbody>
</table>

The results of unit root tests show that both GDP growth and inflation are stationary at levels.

Estimated Equations

The econometric equation shown in equation (1) is estimated through OLS and shown as follows:

\[
y_t = 6.12^* - 0.16^{**} \pi_t
\]

\[
(11.50) \quad (-2.54)
\]

\[
\text{Adj R}^2 = 0.20 \quad \text{F-statistic} = 6.47
\]

Note: Figures in the parentheses show t-values. * and ** denotes coefficients are significant at 1 percent and 5 percent levels respectively.

The simple inflation-growth model shows that there is a negative relationship between GDP growth and inflation because historical data shows high inflation created low growth in several years. But how much inflation is detrimental for GDP growth can be seen by the threshold model. The result of threshold model is summarized in table 3.
To detect the threshold level, we will compare the above 13 estimated equations with minimum residual sum of squares (RSS). The threshold level will determine in that estimated equation where residual sum of squares is minimum. We plotted all RSS against the threshold level in figure 8.

<table>
<thead>
<tr>
<th>( \pi^* )</th>
<th>Variables</th>
<th>Coefficients</th>
<th>T-Statistic</th>
<th>Probability</th>
<th>Adj. R(^2) (RSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.00%</td>
<td>( \pi_t )</td>
<td>1.08*</td>
<td>2.59</td>
<td>0.01</td>
<td>0.27 (60.53)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.35*</td>
<td>-2.99</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>1.92</td>
<td>1.30</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>4.25%</td>
<td>( \pi_t )</td>
<td>1.00*</td>
<td>2.74</td>
<td>0.01</td>
<td>0.29 (58.91)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.30*</td>
<td>-3.20</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>2.05</td>
<td>1.52</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>4.50%</td>
<td>( \pi_t )</td>
<td>0.90*</td>
<td>2.80</td>
<td>0.01</td>
<td>0.30 (57.92)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.21</td>
<td>-3.33</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>2.28</td>
<td>1.84</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>4.75%</td>
<td>( \pi_t )</td>
<td>0.81*</td>
<td>2.86</td>
<td>0.01</td>
<td>0.31 (56.84)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.14</td>
<td>-3.47</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>2.47**</td>
<td>2.16</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>5.00%</td>
<td>( \pi_t )</td>
<td>0.73*</td>
<td>2.88</td>
<td>0.01</td>
<td>0.32 (56.00)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.07</td>
<td>-3.58</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>2.68**</td>
<td>2.52</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>5.25%</td>
<td>( \pi_t )</td>
<td>0.67*</td>
<td>2.92</td>
<td>0.01</td>
<td>0.34 (55.05)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-1.02*</td>
<td>-3.70</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>2.84*</td>
<td>2.86</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>5.50%</td>
<td>( \pi_t )</td>
<td>0.60*</td>
<td>2.91</td>
<td>0.01</td>
<td>0.34 (54.37)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.96*</td>
<td>-3.79</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.02*</td>
<td>3.24</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>5.75%</td>
<td>( \pi_t )</td>
<td>0.54*</td>
<td>2.86</td>
<td>0.01</td>
<td>0.35 (53.94)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.91*</td>
<td>-3.85</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.19*</td>
<td>3.63</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>6.00%</td>
<td>( \pi_t )</td>
<td>0.48*</td>
<td>2.78</td>
<td>0.01</td>
<td>0.35 (53.74)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.86*</td>
<td>-3.87</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.37*</td>
<td>4.03</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>6.25%</td>
<td>( \pi_t )</td>
<td>0.42*</td>
<td>2.67</td>
<td>0.01</td>
<td>0.35(53.71)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.81*</td>
<td>-3.88</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.54*</td>
<td>4.44</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>6.50%</td>
<td>( \pi_t )</td>
<td>0.37**</td>
<td>2.53</td>
<td>0.02</td>
<td>0.35(53.94)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.77*</td>
<td>-3.85</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.71*</td>
<td>4.83</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>6.75%</td>
<td>( \pi_t )</td>
<td>0.32**</td>
<td>2.38</td>
<td>0.02</td>
<td>0.35(54.12)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.73*</td>
<td>-3.83</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.86*</td>
<td>5.21</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>7.00%</td>
<td>( \pi_t )</td>
<td>0.29**</td>
<td>2.26</td>
<td>0.03</td>
<td>0.35(54.10)</td>
</tr>
<tr>
<td></td>
<td>((\pi_t - \pi^*))</td>
<td>-0.69*</td>
<td>-3.83</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \alpha )</td>
<td>3.98*</td>
<td>5.58</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

\( \pi^* \) = level of threshold; \( \pi_t \) = inflation; \( \alpha \) = constant; * and ** over the coefficient values denote these are significant at 1% and 5% levels respectively.
From figure 8, we can easily see that the threshold level might be at a rate of inflation of 6.25 percent among the 13 estimated equations where residual sum of squares (RSS) is minimized. We made diagnostic tests for estimation equation at this level of inflation threshold.

Diagnostic tests
Diagnostic tests were done for the estimated equation shown in equation (3) and the diagnostic results are depicted in table -4 below.

<table>
<thead>
<tr>
<th>Test for</th>
<th>Test Statistic</th>
<th>Probabilities</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Normality</td>
<td>1.34</td>
<td>0.51</td>
<td>Residuals Normally distributed</td>
</tr>
<tr>
<td>(JB test)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Serial Correlation</td>
<td>0.67</td>
<td>0.52</td>
<td>No serial correlation</td>
</tr>
<tr>
<td>(LM test)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Heteroskedasticity</td>
<td>0.76</td>
<td>0.59</td>
<td>No heteroskedastic error</td>
</tr>
<tr>
<td>White (cross terms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (No cross terms)</td>
<td>1.05</td>
<td>0.36</td>
<td></td>
</tr>
</tbody>
</table>

From the diagnostic tests summarized in table-6 we found that there are no serial autocorrelation and heteroskedastic problem in the residual distribution and the residuals are also normally distributed.

Estimation of Quadratic Equation

The quadratic econometric equation shown in equation (5) is estimated through OLS and shown as follows:

\[ y_t = 3.76\pi_t + 0.50\pi_t - 0.04\pi_t^2 \quad --- (7) \]

\[
\begin{align*}
(4.91) & \quad (2.81) & \quad (-3.86)
\end{align*}
\]

\[ \text{Adj } R^2 = 0.37 \quad \text{F-statistic } 11.93 \]

Note: Figures in the parentheses show t-values. * denotes coefficients are significant at 1% level.

From equation (7), we can also find that threshold level is 6.25% as follows

\[ \frac{dy_t}{d\pi_t} = 0.5 - 0.08\pi_t = 0 \quad --- (8) \]

\[ \frac{d^2y_t}{d\pi_t^2} = -0.08, \text{ which is } < 0 \]
Since the both conditions for maximization are satisfied, we can find the threshold level of inflation by solving from equation (8) as follows:

\[ 0.5 - 0.08 \pi_t = 0 \]

Or, \[ 0.08 \pi_t = 0.50 \]

Or, \[ \pi_t = \frac{0.50}{0.08} = 6.25 \]

Diagnostic tests were done for the quadratic equation shown in equation (7) and the diagnostic results are depicted in table-5 below.

<table>
<thead>
<tr>
<th>Test for</th>
<th>Test Statistic</th>
<th>Probabilities</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. <strong>Normality</strong></td>
<td>0.11</td>
<td>0.94</td>
<td>Residuals normally distributed</td>
</tr>
<tr>
<td>(JB test)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. <strong>Serial Correlation</strong></td>
<td>2.53</td>
<td>0.09</td>
<td>No serial correlation</td>
</tr>
<tr>
<td>(LM test)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. <strong>Heteroskedasticity</strong></td>
<td>1.18</td>
<td>0.34</td>
<td>No heterosckdastic error</td>
</tr>
<tr>
<td>White (cross terms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (No cross terms)</td>
<td>1.56</td>
<td>0.22</td>
<td></td>
</tr>
</tbody>
</table>

From the diagnostic tests summarized in table-5 we found that the there are no serial autocorrelation and heterosckdastic problem in the residual distribution and the residuals are also normally distributed.

**Robustness of Tests**

Both the Sarel threshold methodology and non-linear threshold estimation imply the same threshold level which indicates that the results are robust.

**8. Conclusion and Policy Implications**

The study paper has examined the relationship between inflation-economic growths and determined a threshold level of inflation in the case of Bangladesh. In this paper, various threshold equations have been used to diagnose empirically the inflation-economic growth relationship in Bangladesh. The empirical results have indicated that the inflation and economic growth are negatively related according to the historical data. Second, the sensitivity of inflation to changes in growth rates is larger than that of growth to changes in inflation rates. That’s why the policymakers should note that any increase in inflation from the previous period at any level has a negative effect on economic growth.

Empirical results based on time series annual data containing the full sample period (FY1977-2015) show that statistically significant structural break is exists in relation between growth and inflation at 6.25 percent which is very close to the targeted level of inflation (6.2 percent) for FY2015-16. As suggested by Sarel (1996), the existence of such a structural break is suggestive of a specific numerical target for monetary policy conduct by keeping inflation targets below the structural break point. Here the
important point is that macroeconomic stability with sufficient infrastructural facility is the main precondition for sustained growth and an important window is the effect of inflation on investment which can affect growth. Low or moderate inflation indicates the macroeconomic soundness and creates a congenial atmosphere for investment.

However, only low inflation cannot fulfill the sufficient condition for economic growth. In Bangladesh when inflation went down significantly (e.g. in periods from FY2000 to and FY2002), economic growth did not accelerate significantly. Also, evidence shows that higher inflation has a negative impact on private investment in manufacturing. That is why optimal growth can be achieved by controlling inflation and raising private investment side by side. Moreover, the government needs to control budget deficits within reasonable limits. This can be achieved by discouraging government expenditure for unproductive sectors. So it is wise to keep inflation at a tolerable level to achieve the optimum economic growth through reasonable deficit-financing with higher private investments in productive sectors.

However, the question of which level of inflation we should maintain to accelerate optimum growth in Bangladesh, has been empirically answered. The results of the study have important implications for monetary policy conduct for Bangladesh. The study recommends that the Bangladesh Bank should continue pursuing the cautious and growth-supportive monetary policy framework by keeping inflation target below 6.25 percent otherwise Bangladesh’s growth prospects may be hampered. However, the recent trend of inflation shows downward and GDP growth is expected to be higher in the upcoming years. As a result, threshold may be lower.

To tame inflation within growth-enhancing ranges, policy tightening through complementary mix of monetary and fiscal policies is recommended. Prudent fiscal management through controlled public expenditure must be vigorously pursued by paying attention to infrastructural development like the Padma Bridge, extension of new rail lines, establishing of more EPZs (Export Processing Zones) as well as the quality of public and private investments in the economy.

............................
References


World Bank. (2013), World Development Indicators. Washington, USA.